

Preface

Over the last decade, there has been a dramatic increase in the use of computers embedded within and intrinsically part of larger devices. This has led to a metamorphosis from a world of computers that are seen as such and used by humans as distinct machines, into a world of sophisticated, computerized, networked machines that are not seen as computers nor used as such by humans. Estimates indicate that today most computers are of this type. Computers are in telephones, cars, microwave ovens, cash registers, and a multitude of other fanciful and mundane devices and systems. The resulting change in our view of computers and their use by humans is the subject of the field known as pervasive computing.

The subject of this issue is the human side of that pervasive computing metamorphosis. There is an introductory essay followed by eleven papers on the technologies behind pervasive computing and the impact on humans and their use of these new computerized devices. We are indebted to W. S. Ark of the IBM Almaden Research Center in San Jose, California, for her considerable efforts in planning and developing this issue, and her coordination of it and the authors' works.

Ark and Selker introduce this issue with an essay placing the shift to pervasive computing in context with the developments in computerization during the last decade or so, and the resulting impact on the way humans interact with machines. The authors reflect on a number of specific approaches and results that mark the progress toward pervasive computing and provide guidance on what can be done and might yet be done with these technologies.

One arena in which computers have the opportunity for much wider application and beneficial support is the university classroom, which can be understood as an example of any similar human experience where effective recording for later use can be of benefit to the participants as well as others. In a paper on powerful new uses of classroom comput-

erization, Abowd reports the results of extensive experimentation with capturing the lecture experience in an environment supported by ubiquitous computing: Classroom 2000. In particular, the author relates the interaction between what the environment can support and what the users want, arguing that ubiquitous computing must, by its very nature, be driven by human interaction requirements.

Three recent related case studies show how pervasive devices can assist the functioning of large working groups as they take notes on what they discuss and achieve. The studies focused on the value of what might be called collective note taking, in which support devices, such as the CrossPad**, are used in support of a system for shared notes called NotePals. The authors, Landay and Davis, conclude that collective note taking aids the participants and provides a far more useful record of events.

In a paper by Baber, Haniff, and Woolley, the authors discuss and document numerous approaches being taken toward wearable computers, a clear example of pervasive computing at its most personal level. They contrast these systems across two dimensions that the authors refer to as time, as expressed in the currency of the information used, and reference, as expressed in the type of use. These dimensions form the basis for a method applied in this paper for the design of wearable computer systems for paramedics and fire fighters.

Mobile computing is another example of pervasive computing, and one in which users' needs dictate the design and value. In a paper by Zimmerman, the potential for wireless communication is explored in light of what requirements are placed on the devices by their portability and the need for humans to carry or supply whatever physical resources are required.

Eustice et al. take the issue of wireless communication to its logical conclusion: a universal information appliance (UIA) that is capable of accessing any other systems, databases, services, and devices di-

rectly from the user's portable device. The authors provide an architecture for such UIAs, utilizing IBM's TSpaces* software. They describe the characteristics of UIAs along the dimensions of user interface, wireless infrastructure, and communications middleware.

A person moving around in the world could well ask of their personal, wireless, mobile system that it provide information on and context reflecting the physical place where that person is, resulting in an augmented experience for the user. As an example, consider the possibility that the user's portable system would allow the experience of watching the sky to be augmented with an overlaid map of the constellations in view at that time and place. Spohrer reflects on the state of such possibilities today and describes WorldBoard as an infrastructure for supplying data that are relevant to place.

Barrett and Maglio present another view of how information systems can support users in pervasive ways. Their view includes intermediaries, which are systems involved in the flow of information in ways that enhance that information or flow for the users. The authors describe such systems and, in particular, an already-implemented Web intermediary framework with applications.

Browsing documents and document-like information on computers is not only a common activity in today's world, but one for which computerized support has not yet matured sufficiently to make it easy and effective. Zhai and Smith provide a paper on a study they conducted on document scrolling methods, measuring their ease of use and effectiveness at achieving the intended information result. Three methods are examined from the perspective of human factors, and the results are reported as a guide for further developments in information perusal systems.

The social aspects of pervasive computing, and the cost to humans of participating in an electronic world, bear examination as the technologies become more sophisticated and available and as the resulting systems become more accessible and ubiquitous. Will these systems enhance or inhibit social interaction? Dryer, Eisbach, and Ark address such questions from the point of view of four types of computerized environments, report on two studies of the impact, and propose a model for the influence of pervasive computing on humans and communities.

In a paper by Mark, the author sets pervasive computing in the larger context of the full environment in which pervasive computing plays a role. If pervasive computing has the effects imagined today, humans will not only have a far different kind of relationship with information and computers, but that relationship will pervade much more of our lives and in many more ways than today. The author focuses on the notion of mediated space, in which pervasive computing assists and augments human interactions, participating in the context and the act of human communication. The paper lays out research challenges that lie ahead in achieving this vision.

This progress has not been, and the future will not likely be, the result of sudden accomplishments. There is a history of pervasive computing that reflects how different it is from what came before and how challenging it is to change the computing paradigm, let alone the more pervasive paradigm of human interaction. The authors of this paper—Weiser (recently deceased), Gold, and Brown—lay out the historical context as it evolved in the late 1980s at the Xerox Palo Alto Research Center, better known as Xerox PARC.

The next issue of the *Journal* will be on the performance aspects of Java**, including Java-specific issues, systems-specific issues, and case studies.

Gene F. Hoffnagle
Editor

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